Mars Sample Return Containment Assurance

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This presentation will describe the issues associated with assuring a high probability that no Mars sample material will be inadvertently released into the Earth's biosphere prior to certification that there is no hazard posed. The presentation will also discuss the steps that had been planned to provide sample containment assurance for the now defunct 03/05 Mars Sample Return Project and ongoing technology development work in related areas.

Sample return from Mars or other planetary bodies requires sealing of the sample container with no external contamination by Mars material and controlled flight through the Earth's atmosphere, successful landing, and recovery. While sample return capsules have been developed for the Stardust and Genesis missions, neither of these missions dealt with the stringent set of containment assurance requirements of a Category V (restricted Earth return) mission. In the former Mars Sample Return Project, initial guidance was given by the NASA Planetary Protection Officer which stated,

> *"The sample return canisters ... shall be sealed to an integrity which for planning purposes should be such that the probability of releasing a ≥0.2 μm particle into the Earth's biosphere is $<10^{-6}$. The ... system should be able to maintain the required seal integrity under all nominal environmental conditions and under non-nominal operational conditions to the degree that the combined probability of inadvertent release into the Earth's biosphere is maintained at $<10^{-6}$."*

The following risk elements will be discussed:

- Sample Container
  - Seal fault or inability to confirm closure
  - Exterior contaminated during loading or by dust from ascent vehicle fairing
  - Breach on landing impact
- Earth Entry Vehicle (EEV)
  - Lid closure fault or inability to confirm closure
  - Exterior contamination
  - Thermal protection system or structural fault
  - Landing impact protection system fault
- Micrometeoroid damage
  - To the sample container
  - To the EEV thermal protection system

- Spin eject fault leading to off-nominal Earth entry

- Miss Earth entry corridor due to
  - Navigation fault
  - Carrier spacecraft fault
  - Operations fault

- Landed sample not recovered by NASA

- Wave-off condition not detected or not acted upon

- Waved-off or contaminated carrier spacecraft re-encounters Earth

Also discussed will be a probabilistic risk assessment (PRA) effort used to quantify the risk contribution of the various elements and to serve as a guide in prioritizing among risk mitigation options.

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